Determining Hearing Protection Effectiveness

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Noise

- Noise is the most prevalent occupational health hazard in the Navy and Marine Corps.
- Prevention of noise induced hearing loss has been a high priority for many years.
- Preferred control method has been hearing protective devices (HPD).
- Effectiveness of HPD has largely been undetermined.

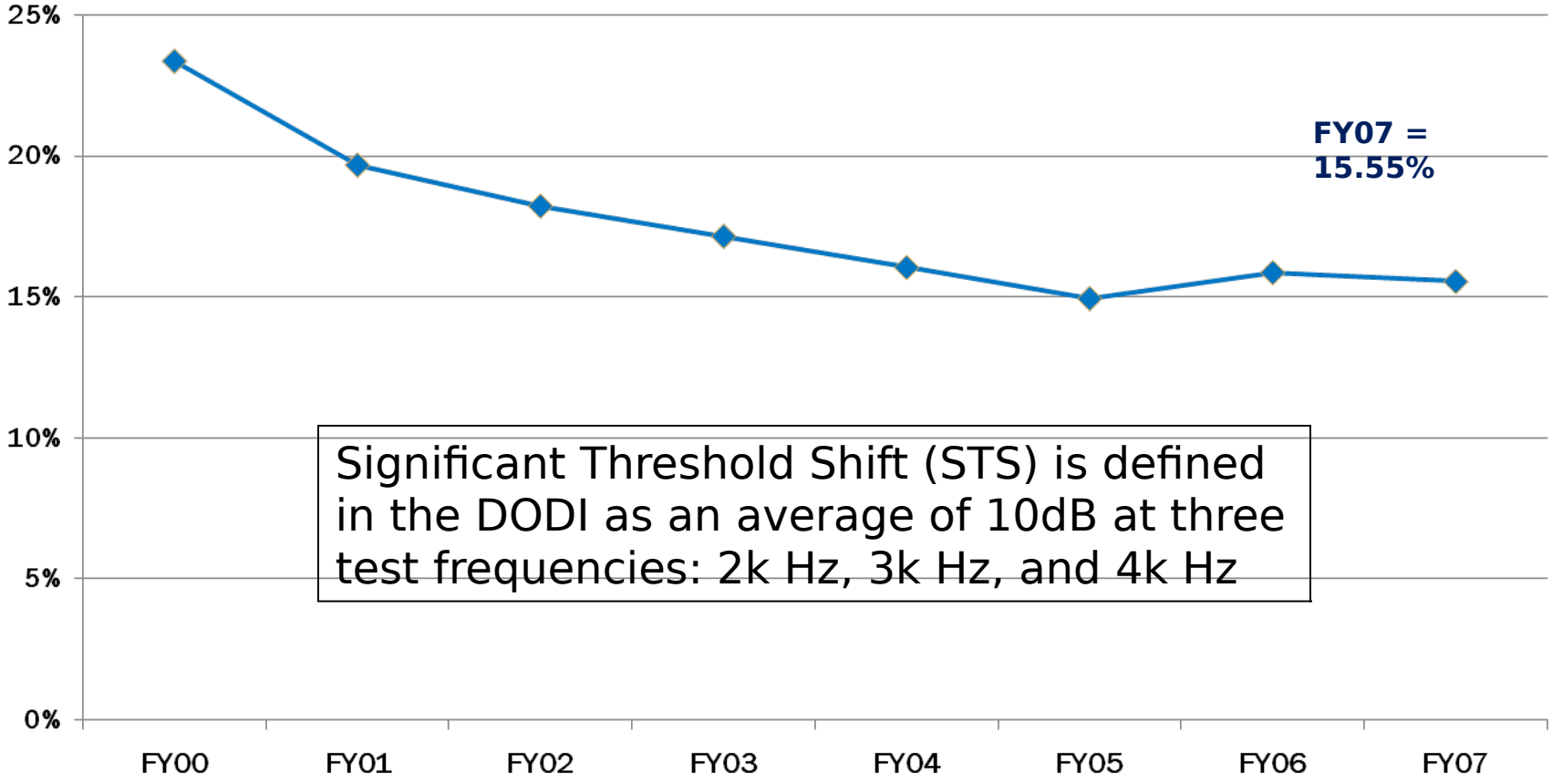
Navy Program

- OPNAVINST 5100.23G Chapter 8 and 18 detail responsibilities for Hearing Conservation
  - Establishes Occupational Exposure Levels (OELs), requires measurements, and exposure assessments
  - Establishes labeling, training requirements
  - Establishes audiometric testing requirements
  - Requires PPE and engineering controls
- How successful is the program?

NIHL as a Pocket Book Issue

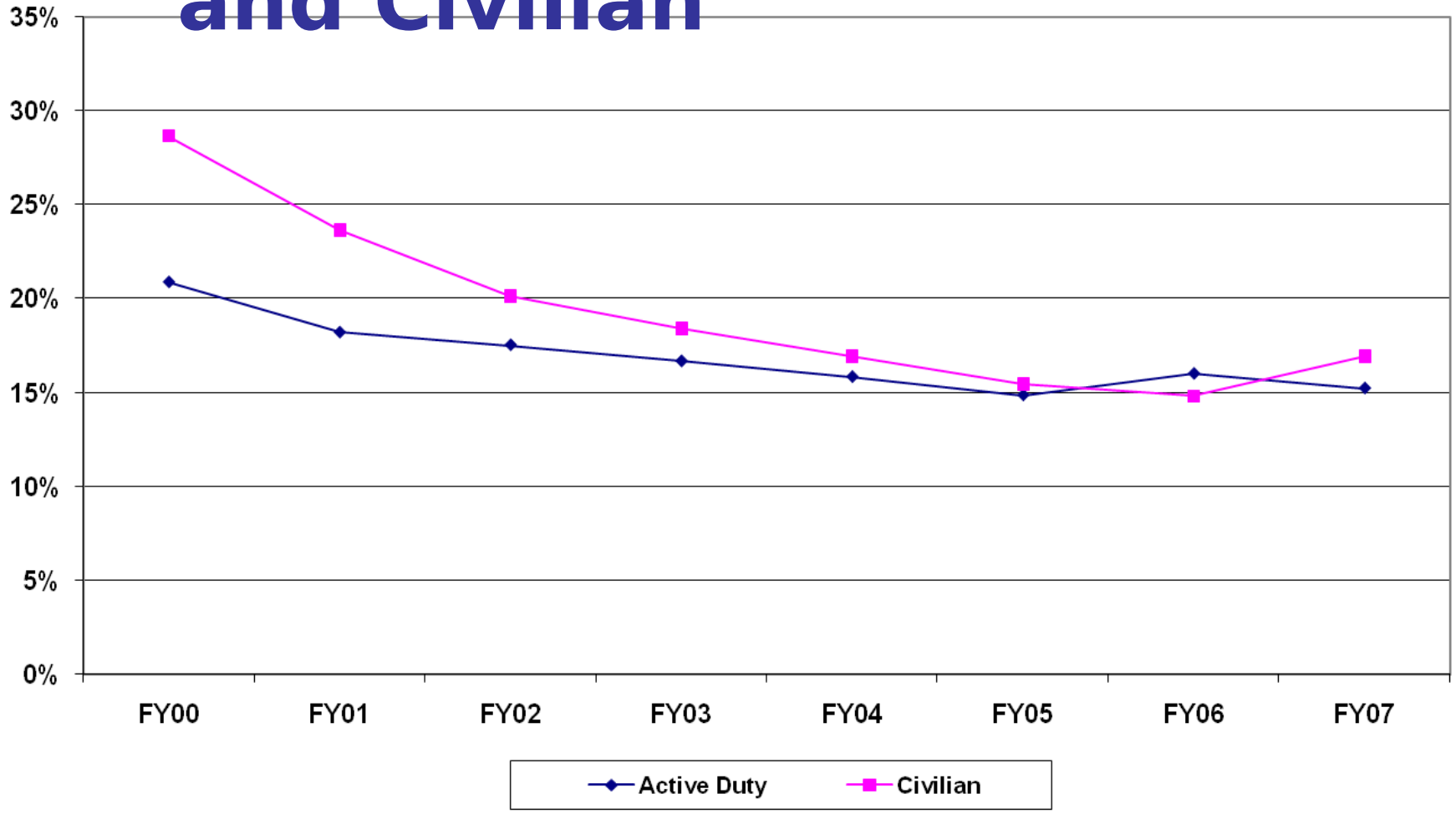
- Over past 10 years VA has paid out nearly $8.4 billion to DoD service members in NIHL and tinnitus disability benefits.
- Disability benefits in 2006 totaled nearly $1 billion, $235 million went to Navy and Marine Corps
- New DoN hearing loss cases filed with VA exceeded 16,000 in 2006

Navy Significant Threshold Shift Rates: All Personnel



Updated 20 FEB 08

Navy Significant Threshold Shift Rates: Active Duty and Civilian



Reasons for NIHL

- What has been identified as reasons for the extent of hearing loss seen?
- Not wearing or not properly wearing PPE
  - Enforcement, training
- Unprotected off-duty exposure
  - Music
  - Cars, motorcycles, boating
  - Hunting, target shooting
  - Lawn mowers, leaf blowers, weed whackers

Reasons for NIHL

- Hearing protective devices (HPD) are the predominant control mechanism employed to protect workers.
  - Engineering controls - retrofit not common
  - Administrative controls
- Are they adequate for the exposure received ?
  - Chapter 8 of 23G requires BUMED IH to evaluate and determine adequacy of existing controls.
  - For HPD-- How to do that?

How to determine adequacy of HPD

- We looked at two basic ways of determining HPD effectiveness
  - Looked at ways to use published values of attenuation (NRR) and compare to actual measured noise levels
  - Looked at a measurement system that determines HPD attenuation (PAR) for individuals

NRR (Noise Reduction Rating)

- If we put someone in a half mask respirator for protection against dust, what is the assigned protection factor for that mask/filter combination?
- **Ten** - regardless of respirator manufacturer
- If, on the other hand, if an employee uses earplugs, what is the "assigned protection factor" for that plug?
- It depends on who made the plug

NRR (Noise Reduction Rating)

- The NRR is a single number rating which EPA requires to be shown on the label of each hearing protector sold in the United States.
- The values of NRRs are determined in accordance with ANSI S3.19-1974, "American National Standard for the Measurement of Real-Ear Hearing Protector Attenuation and Physical Attenuation of Earmuffs."
- In theory, the higher the NRR, the higher the attenuation provided
- The NRR is independent of the noise spectrum in which it is applied.

How to Use the NRR- Adequacy

- Appendix A of Ch18 of 23G and Appendix B of 29 CFR 1910.95
  - Estimated 8-hr TWA under protector (dBA) = TWA (dBA) - (NRR -7)
  - The 7 dB correction factor accounts for the de-emphasis of low frequency energy inherent to the A weighting scale
- Example: 8 Hr TWA = 92 ; NRR = 23
  - Estimated TWA = 92 - (23-7) = 76 dBA

How to Use the NRR- Relative Performance

- OSHA's experience and the published scientific literature have shown that NRR values for HPDs are not consistently achieved in the workplace. To adjust for workplace conditions, **OSHA recommends a 50% correction factor**
  - Estimated 8-hr TWA under protector (dBA) = TWA (dBA) - [(NRR - 7) x 50%]

    Example: 8 Hr TWA = 92 ; NRR = 23

    Estimated TWA = 92 – [(23-7) X 0.5] = 84 dBA

How to Use the NRR- the NIOSH way

- Using NIOSHs method, the NRR is adjusted by the type of HPD (see "Criteria for a Recommended Standard, Occupational Noise Exposure, *Revised Criteria 1998* " NIOSH, 1998)
- Earmuffs = subtract 25% from the MFR NRR

  Estimated 8-hr TWA under protector (dBA) =

  TWA (dBA) - [(NRR - 7) x 75%]
- Formable plugs = subtract 50% from the MFR NRR

  Estimated 8-hr TWA under protector (dBA) =

  TWA (dBA) - [(NRR - 7) x 50%]
- All other plugs = subtract 70% from the MFR NR

  Estimated 8-hr TWA under protector (dBA) =

  TWA (dBA) - [(NRR - 7) x 30%]

Correcting the NRR

- Both OSHA and NIOSH recommend correcting (derating) the NRR
- Corrections range from 25% to 70%
- Where did these corrections come from?
- Table 6-1 of the Criteria for a Recommended Standard, Occupational Noise Exposure, *Revised Criteria 1998* " NIOSH, 1998)
  - Summary of 20 independent studies

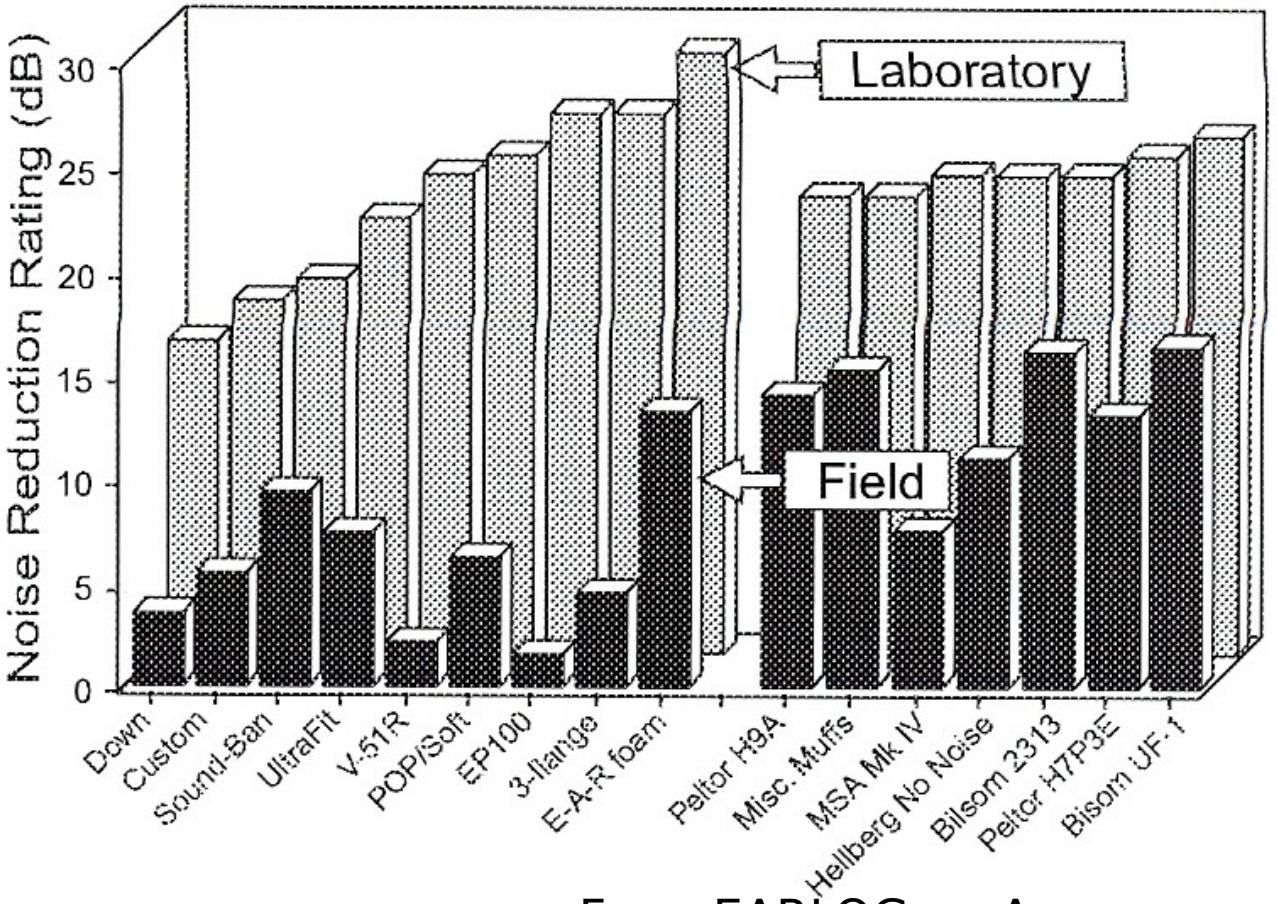
http://www.cdc.gov/niosh/docs/98-126/chap6.html#table61

Table 6–1. Summary of real-world NRRs achieved by 84% of the wearers of hearing protectors in 20 independent studies*

Type of hearing protector, model, and reference	Test population (number)	Labeled NRR*	NRR84	Weighted mean NRR84*	Mean NRR84
Foam:					
E-A-R	—	—	—	12.5	13.2
Crawford and Nozza [1981]	58	29	19	—	—
Hachey and Roberts [1983]	31	29	9	—	—
Lempert and Edwards [1983]	56	29	12	—	—
Edwards and Green [1987]	28	29	19	—	—
Edwards and Green [1987]	28	29	14	—	—
Lempert and Edwards [1983]	56	29	5	—	—
Abel et al. [1978]	55	29	9	—	—
Abel et al. [1978]	24	29	9	—	—
Behar [1985]	42	29	14	—	—
Behar [1985]	24	29	16	—	—
Pfeiffer et al. [1989]	69	29	10	—	—
Casali and Park [1991]	10	29	6	—	—
Casali and Park [1991]	10	29	23	—	—
Hempstock and Hill [1990]	72	29	13	—	—
Berger and Kieper [1991]	22	29	20	—	—

Correcting the NRR

Figure 1 - Comparison of NRRs published in North America (labeled values based upon laboratory tests), to real-world "field" attenuation results derived from 20 separate studies.



From $EARLOG_{20}$ – Aearo Company Elliot H. Berger

Field Study Using the NRR

- Wanted to see how effective HPD are in actual field situations using the NRR and it's associated corrections.
  - Modified noise dosimetry form and data entry screen for noise dosimetry to collect NRR data
  - In September 2007 began collecting the NRR of the HPD worn when noise dosimetry was performed when doing periodic exposure assessments
  - Apply the correction factor and determine incidence of inadequate protection

NRR - Navy Criteria 84 dBA and 4 dB exchange

- 269 noise dosimetry 8 hr TWAs 36 activities
- 121 > 84 dBA 8 hr TWA

- 50% correction [8 hr TWA- (NRR-7)/2]
  - 45 instances or **37%** HPD did not attenuate to <84
- No 50% correction [8 hr TWA-(NRR-7)]
  - 18 instances or **15%** HPD did not attenuate to <84

NRR – DOD Criteria 85 dBA and 3 dB exchange

- 269 noise dosimetry 8 hr TWAs 36 activities
- 156 > 85 dBA 8 hr TWA (58%)
- 50% correction [8 hr TWA- (NRR-7)/2]
  - 60 instances or **38%** HPD did not attenuate to <85
- No 50% correction [8 hr TWA-(NRR-7)]
  - 21 instances or **13%** HPD did not attenuate to <85

NRR Field Study-Summary

- When using the NRR to determine degree of effectiveness:
  - HPD are ineffective between 15% and 37% of the time when 8 hour TWA exposures exceed 84 dBA

Personal Attenuation Rating (PAR) FITCheck

- NMCP Occupational Audiology Department has obtained equipment that allows the attenuation of insert type hearing protectors to be measured on individuals.
- Essentially equivalent to a respirator fit-test
- Provides attenuation **actually** provided to user by a specific insert type HPD
- Referred to as a Personal Attenuation Rating or PAR

PAR System Trial

- 10 test subjects, IH personnel
  - All have worn HPD devices for many years
- Five different HPD
- OA Department Head conducted tests
- All 10 IHs were tested with all five HPD

FITCheck System

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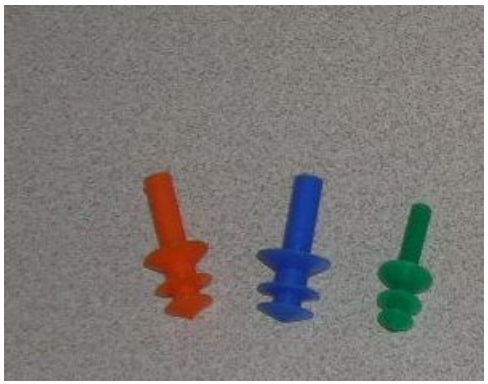
FITCheck System

Hearing Protection Tested

Single Flange-NRR=23

Pelter Skull Screw- NRR= 30

Elevex Quattro- NRR= 2



Triple Flange-NRR=26

Aearo Classic-NRR= 29

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FitCheck –Personal Attenuation Ratings for 10 Individuals in dB

Subject	*Classic*	*Quattro*	*Single*	*Skull Screw*	*Triple*
NRR	29 dB	25 dB	23 dB	30 dB	26 dB
A	32	27	24	23	19
B	17	24	25	12	23
C	23	22	28	17	32
D	27	21	--	12	--
E	13	20	17	--	--
F	23	27	19	30	23
G	25	22	23	27	17
H	11	27	23	18	19
I	22	25	12	24	--
J	10	17	23	--	--

– subject fit test PAR were negligible

Personal Attenuation Rating PAR—Intended Use

- Estimated Exposure dBA=[8 hr TWA]-[PAR-7]
- Example: 8 hr TWA = 90 PAR = 26

Estimated exposure = 90-[26-7]= 71 dBA

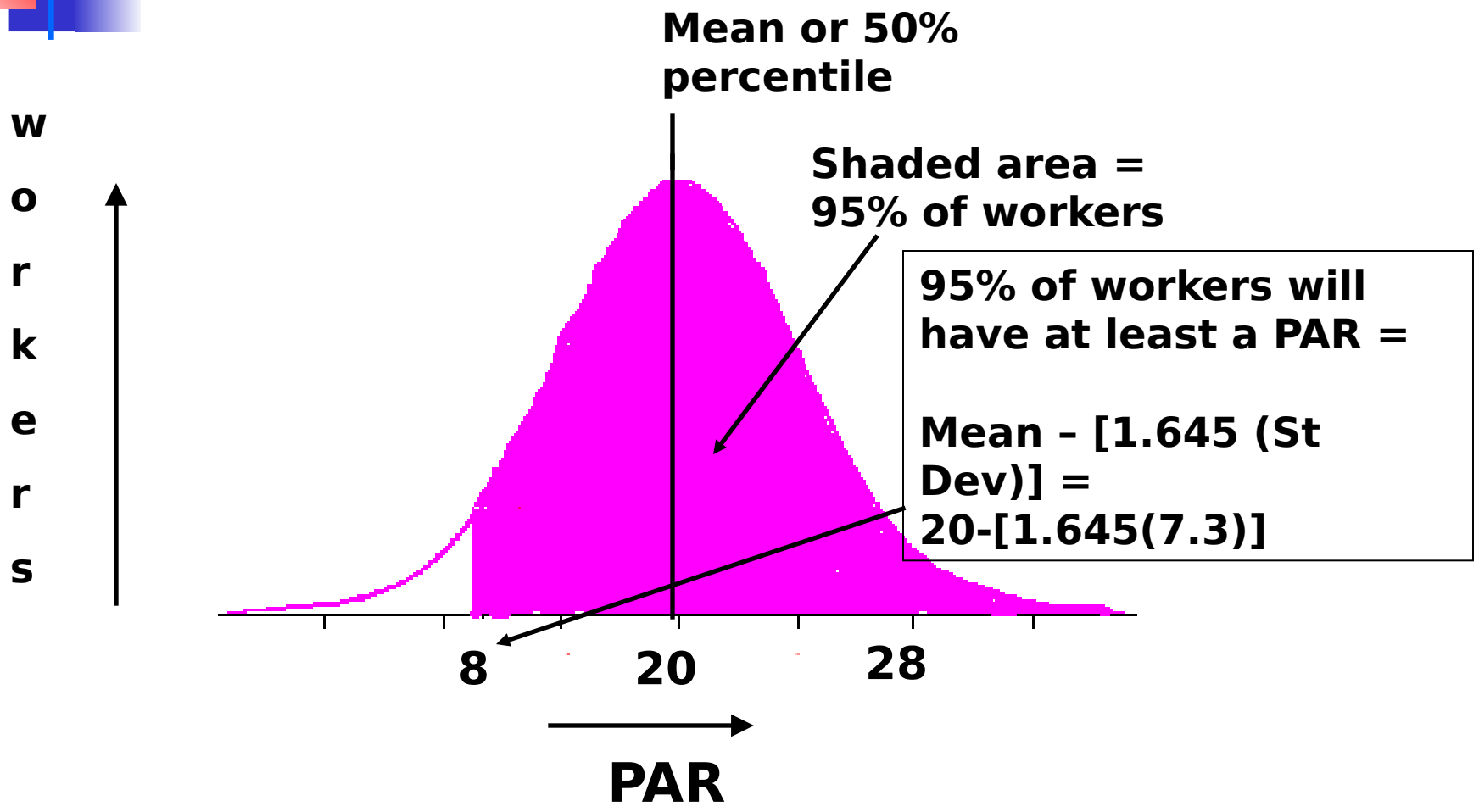
- Specific to an individual
- Provides a measure of attenuation a particular HPD offers for that individual
- Measured in dB

PAR –Potential Extended Use

- Don’t have data for all workers
- Can you use data for untested workers?
- Want to be reasonably assured that attenuation can be achieved by ~95% of workers
- Need to use statistitics

	Classic	***Quattro***	***Single***	***Skull Screw***	***Triple***
NRR	**29**	**25**	**23**	**30**	**26**
Mean	***20.3***	***23.2***	***21.6***	***20.4***	***22.2***
Range	***10-32***	***17-27***	***12-28***	***12-30***	***17-32***
Std Dev	***7.3***	***3.4***	***4.8***	***6.7***	***5.4***

Example ---Classic



PAR –Potential Extended Use

	Classic	*Quattro*	*Single*	*Skull Screw*	*Triple*
NRR	29	25	23	30	26
Mean	***20.3***	***23.2***	***21.6***	***20.4***	***22.2***
Range	***10-32***	***17-27***	***12-28***	***12-30***	***17-32***
Std Dev	***7.3***	***3.4***	***4.8***	***6.7***	***5.4***
P 95%*	***8 dB***	***18 dB***	***14 dB***	***9 dB***	***13 dB***

P 95% = Calculated attenuation achieved by at least 95% of wearers

PAR vs NRR

	Classic	*Quattro*	*Single Flange*	*Skull Screw*	*Triple Flange*
NRR (dB)	**29**	**25**	**23**	**30**	**26**
Mean PAR (dB) **(50% ile)**	***20.3***	***23.2***	***21.6***	***20.4***	***22.2***
P 95% (dB) **(mean-1.645*std)**	***8***	***18***	***14***	***9***	***13***
P 95% (dbA) **(P 95% – 7)**	***1***	***11*** **95**	***7*** **9** **1**	***2*** **86**	***6*** **90**
Corrected NRR (dBA) **(NRR-7)/2**	***11***	***9***	***8***	***11.5***	***9.5***

PAR Population Use

- Estimated Exposure dBA=[8 hr TWA]-[PAR-7]
- The estimate for group PAR would have to be represented by either the 95th or 98th percentile of the group data.
- Inherent variability between individuals makes the percentile PAR estimates for some HPD fairly small.
- HPD that show low variability in PAR in absence of individual testing would make good candidates for use

PAR Population Use

- Questions of what data to use for population PAR?
  - NMCP OA will use FIT Check for those individuals whose baseline is reset
  - Who fits the plug before testing?
- Noted best fit achieved by plug best liked by wearer.

Conclusions

- Individual fit test (PAR) best method to ensure HPD effectiveness
- Where HPD fit test (PAR) is used selectively
  - Data can be used to determine which HPD have the least variability between individuals. These HPD should be recommended.
- If individual fit not used or in developmental stage, use 50% correction to help guide HPD choices.
- Really need to engineer noise out.